

Fishery Data Series No. 91-68

Stock Assessment of Dolly Varden in the Buskin River, Kodiak, 1990

by

Mary E. Whalen

November 1991

Alaska Department of Fish and Game

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ABSTRACT

During 23 April-16 July 1990 a weir was operated at the outlet of Buskin Lake to estimate abundance, growth, length distribution, maturity state, and run timing of Dolly Varden *Salvelinus malma*. A total of 90,600 Dolly Varden emigrated through the weir, 7,492 were tagged and 1,037 were recaptured from previous tagging. A creel survey was conducted 23 April to 25 May 1990 on the Buskin River. Anglers fished an estimated 4,268 hours and harvested an estimated 2,362 adult Dolly Varden. The weir was moved to the lower Buskin River on 16 July. Of the Dolly Varden entering the Buskin River on 18 and 19 July, 48.2% were mature. Total immigration of Dolly Varden could not be estimated because of an extensive weir washout and because fish continued to enter the river into the fall. A spawning ground survey on the American River found 3,947 Dolly Varden. Surveys of the Buskin River system discovered spawning Dolly Varden at the northwest end of Buskin Lake.

KEY WORDS: Buskin River, Dolly Varden, *Salvelinus malma*, abundance, growth, length, maturity, effort, harvest.

INTRODUCTION

The Buskin River (Figure 1), near the city of Kodiak, is the most intensively fished river on Kodiak Island. In 1989, approximately one-half of the fresh-water sport fishing effort on Kodiak Island occurred on the Buskin River (Mills 1990). Angler effort on the Buskin River is directed toward Dolly Varden *Salvelinus malma*, coho salmon *Oncorhynchus kisutch*, sockeye salmon *O. nerka*, and pink salmon *O. gorbuscha*. The Dolly Varden sport harvest ranged from 5,293 to 15,150 fish during the period 1977 through 1989 (Mills 1979-1990).

Buskin Lake (Figure 2) is the major overwintering area for Dolly Varden from tributaries throughout Chiniak Bay. This "super-population" of Dolly Varden that overwinter in Buskin Lake emigrate from Buskin River in the spring to feed in marine waters during summer. Some enter other streams to spawn before returning to the lake to overwinter again in the fall (Sonnichsen 1990). Historically, the Buskin River was not thought a significant spawning stream, with as few as 500 Dolly Varden observed spawning in all Buskin tributaries (Marriott 1965). We suspected that, in reality, a substantial number of Dolly Varden spawn in the Buskin River because only 15% of all adult fish in the super-population spawn in the American and Olds rivers, and tributaries in Chiniak Bay. Also, preliminary sampling done on the Buskin River in October 1988 indicated that 26% of the females were mature (S. Sonnichsen, Alaska Department of Fish and Game, Anchorage, personal communication). Dolly Varden found in the Buskin River contribute to sport fisheries throughout the Chiniak Bay area. Depletion of the Dolly Varden population in the Buskin River could result in a reduction in the number available for sport harvest in all of the Chiniak Bay streams.

This is the sixth year of a long-term study of the Dolly Varden fishery in the Buskin River. Since inception, work on this project has concentrated on developing a model of stock structure for this resource. An important aspect of this model is to determine if spawning occurs significantly at locations other than the American and Olds rivers. The ultimate goal is to estimate key parameters of the super-population of Dolly Varden that overwinter in Buskin Lake. Eventually, data from many years will be used to estimate abundance, recruitment, survival, fishing mortality, and sustained yield. This document is an interim working report to account for methods and results of the 1990 season.

Specific objectives for the 1990 study were to:

1. census the emigration of Dolly Varden 200 mm or longer (fork length) through the weir on the Buskin River from mid-April through mid-June;
2. estimate length compositions of Dolly Varden during the entire spring emigration and for 4 weeks during the summer immigration;
3. estimate the sport fishing harvest of Dolly Varden on the Buskin River during the spring fishery, from mid-April to late May;
4. census the immigration of Dolly Varden 300 mm or longer through the Buskin River weir during July and August;

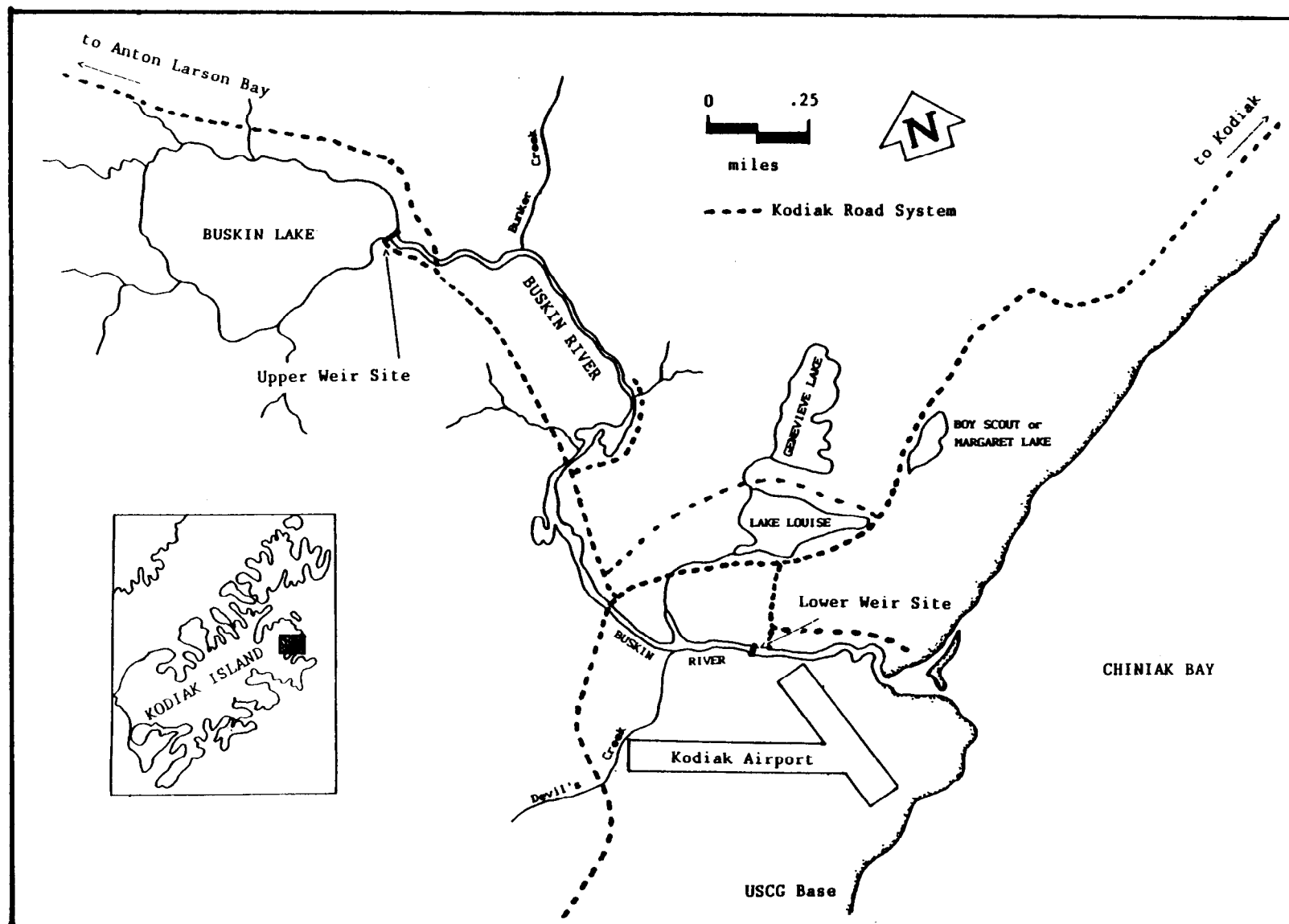


Figure 1. Buskin River, Kodiak Island, Alaska.

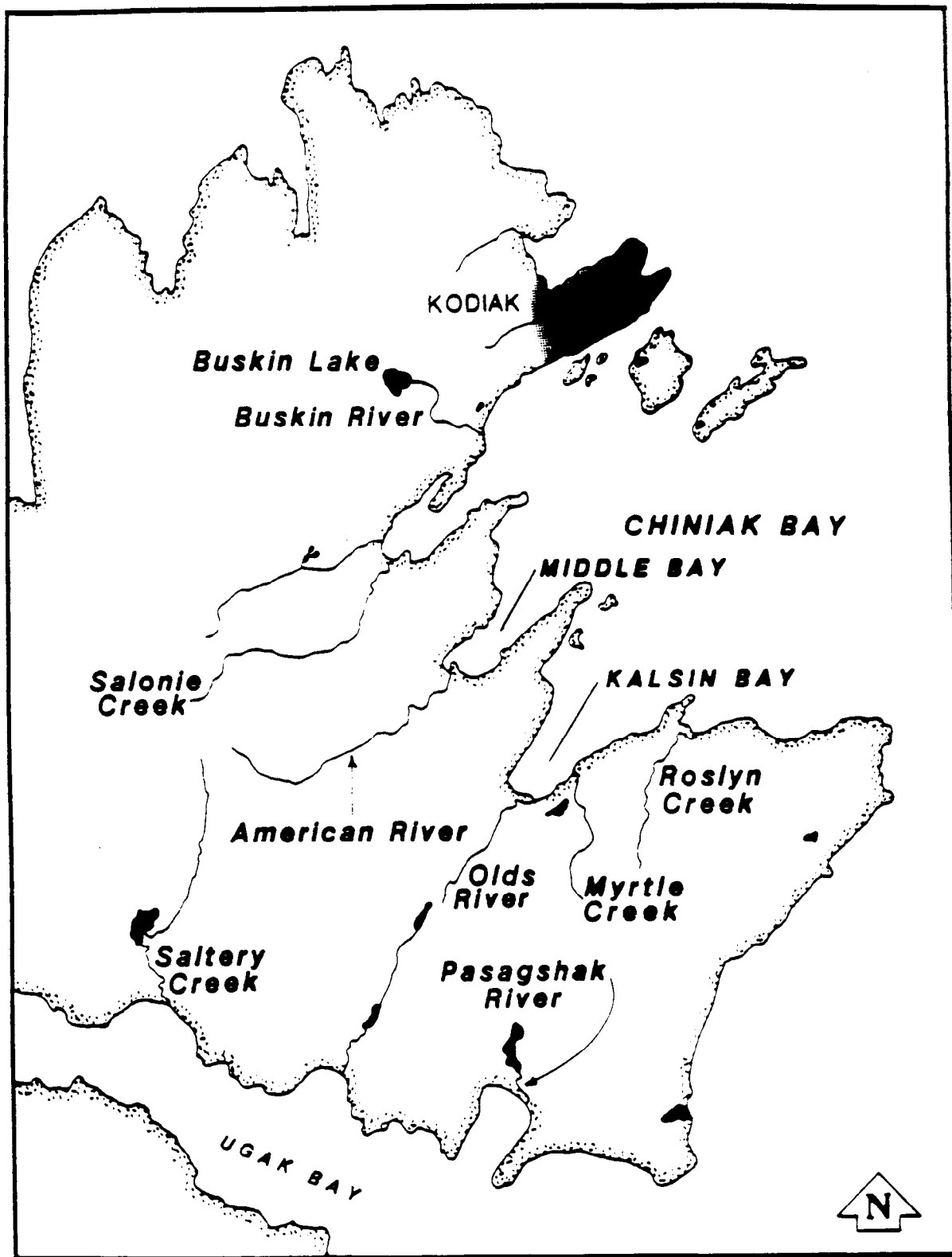


Figure 2. The Chiniak Bay area, Kodiak Island, Alaska.

5. estimate relative maturity of immigrating female Dolly Varden with two instantaneous samples during late July to early August; and
6. estimate the spawning abundance of Dolly Varden in the American and Olds rivers during early October. Also, attempt to locate spawning populations of Dolly Varden in the Buskin River in early October.

METHODS

To achieve our objectives, the following activities were undertaken: a weir was constructed at the outlet of Buskin Lake and Dolly Varden were counted, measured, and tagged as they outmigrated; a creel survey was conducted on the sport fishery; two maturity samples were taken from immigrating fish after the weir was moved to the lower Buskin River; and a spawning ground survey was conducted in October on the American, Olds, and Buskin rivers. Data files used to produce all estimates in this report are listed in Appendix A.

Buskin River Weir

Dolly Varden emigration was assessed with the use of an aluminum picket weir overlaid with 1 inch Vexar plastic mesh. A trap was incorporated into the weir to facilitate the capture and retention of Dolly Varden. The weir was installed at the outlet of Buskin Lake on 23 April and kept in place until 16 July. The initial portion of the emigration was missed as evidenced by the presence of Dolly Varden caught in the downstream sport fishery before weir installation. This information came from personal communications with sport fishermen. The number of fish missed was probably low because few fish were leaving the lake at the beginning of weir operation. On 5 June, the Vexar was mistakenly removed from the weir. A complete count of Dolly Varden was obtained between the dates of 25 April and 5 June.

A small number of tagged Dolly Varden were captured at the weir more than once. These represent fish that passed through the weir once, went back up through the weir and were counted a second time as they returned downstream. Daily weir counts were reduced to account for fish that were counted twice as follows:

$$W_{t2}^* = W_{t2} - W_{t1}^* (R_{t1} / N_{t1}) \quad [1]$$

where:

- W_{t2}^* = the adjusted weir count for day t2,
- W_{t2} = the total number of fish counted through the weir on day t2,
- W_{t1}^* = the adjusted weir count for day t1,
- R_{t1} = the number of recaptures (on day t2) of fish tagged at the weir on day t1, and
- N_{t1} = the number of fish tagged at the weir on day t1.

On 16 July, the weir was moved to 1.4 km upstream of tidewater to more accurately assess the pink salmon and coho salmon runs. The Vexar was not in place when the weir was at its lower site due to washout possibilities. Without the Vexar in place, the weir did not reliably stop fish under 300 mm. On 1 August the Buskin River weir washed out at the lower site. Extreme high water eroded the shoreline significantly, making it impossible to replace the weir until 14 August.

Immigrating Dolly Varden were counted through the weir during 16 July to 1 August and 14 August to 26 September. This was not a complete census because of weir washout, lack of Vexar on the weir, and because immigration of Dolly Varden extended into fall when the weir was not in operation.

Tagging Operation

Our objective during emigration was to tag approximately 10% of the fish passing through the weir with numbered green Floy FD 68B anchor tags, and to examine these fish for adipose fin clips. Dolly Varden were tagged and adipose fin clipped during the spring and fall sampling events in 1989 to initiate a tag loss study (Sonnichsen 1990). Tag loss estimates were calculated using the following equation:

$$\text{tag loss} = \frac{\# \text{ of fish missing a tag and adipose from this sample}}{\# \text{ of fish recaptured from 1989 season in this sample}}$$

An additional 20% of the Dolly Varden were to be examined for the presence of a tag. Due to high water near the end of the emigration (Figure 3), these percentages were not met, giving a final sample size of 8.27% Dolly Varden tagged and 25.18% examined.

Length Composition

During emigration 8,124 Dolly Varden were tagged and measured. Chi-square tests were used to test the null hypothesis that the length distributions did not differ among weeks. During the immigration, a minimum of 100 fish per week were measured for 3 weeks during the peak of the run. Kolmogorov-Smirnov two-sample tests were used to test that lengths did not differ among weeks. Total sample size was 401.

A test to determine minimum size of Dolly Varden stopped by the weir during the emigration was performed. Length and girth measurements were taken on 113 fish and an attempt was made to gently push the fish through the Vexar. Girth was measured around the thickest portion of the body anterior to the dorsal fin.

Relative Maturity

To assess the likelihood of a major spawning population in the Buskin River, the percent of mature females was estimated during immigration. Due to the washout of the weir on 1 August, only one sample of 191 Dolly Varden was taken on 18 July and 19 July. Otoliths of all fish sampled, male and female, were taken to ascertain age at relative maturity. (Age determinations are

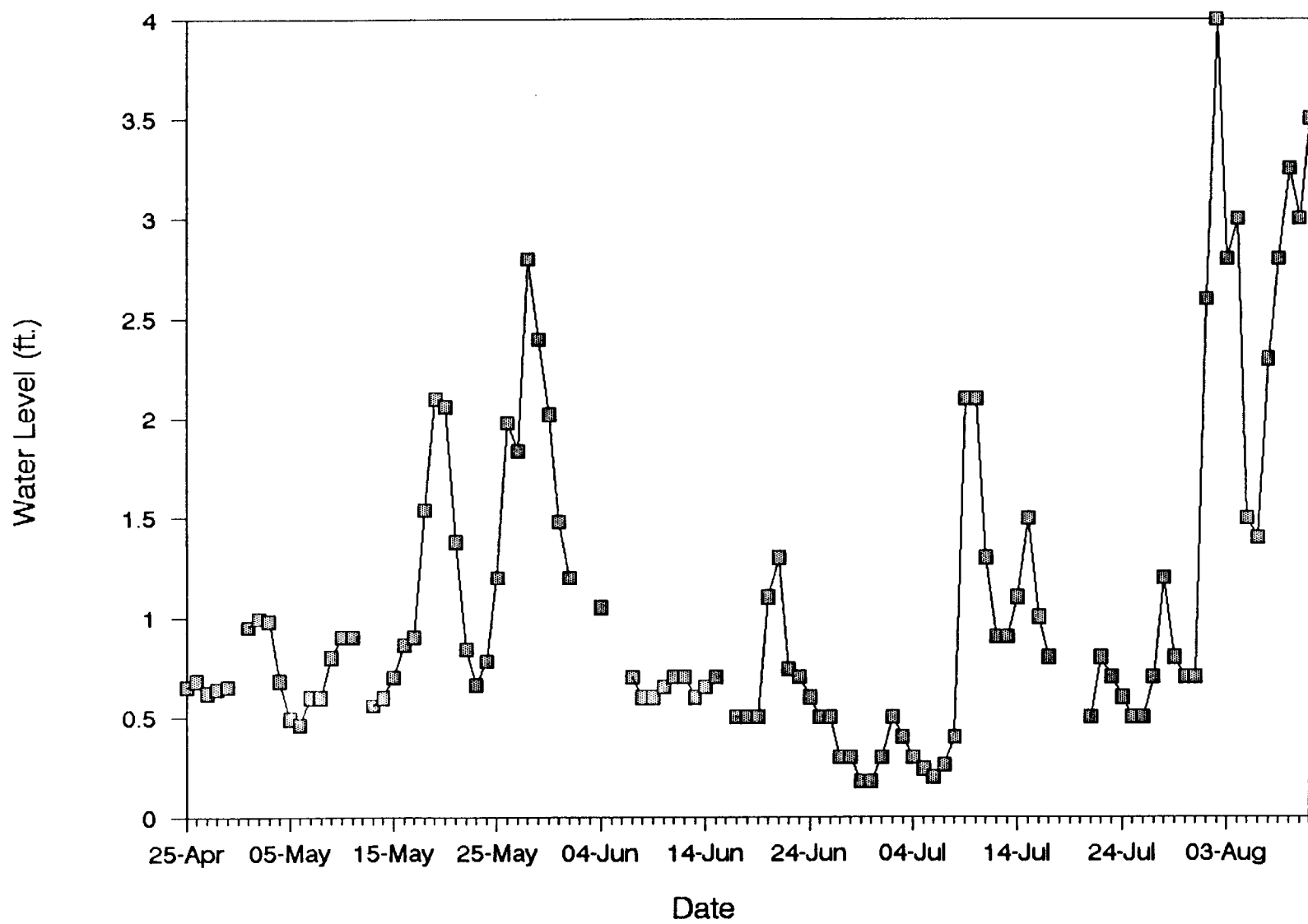


Figure 3. Buskin River water level for spring and summer of 1990.

not available for this report and will be done at a later date.) A sample of 95 Dolly Varden was also taken at the outlet of Buskin Lake during the fall spawning ground surveys. Maturity estimation was accomplished through examination of the ovaries using criteria described by Blackett (1968):

- State I. Immature female: completely undeveloped ovary, eggs minute (usually less than 0.90 mm in diameter) and yolkless.
- State II. Maturing female: maturing ovary will develop by spawning period, eggs usually larger than 1.75 mm in diameter and appear to be approaching an advanced stage of maturity. Oil droplets are present in the eggs and vessel structure is well developed in the ovarian tissue.
- State III. Completely mature female: ovaries have reached a degree of maturity allowing the eggs to be easily stripped from the fish with only slight pressure.
- State IV. Completely spawned female: only vestiges of recently spawned eggs in the ovary; i.e., ovary appears as a string with many minute recruitment eggs embedded in the tissue.
- State V. Immature female but shows a degree of development: ovaries do not appear as if they would mature this year but development is definitely more advanced than State I. Egg diameters are usually greater than 0.90 mm but less than 1.75 mm. Ovary size is large enough to indicate spawning next year.

Creel Survey

Estimates of catch, harvest, effort, and length composition of fish caught in the sport fishery were obtained through the Buskin River creel survey using a stratified systematic sample design. Angler counts and interviews were conducted using a roving creel survey. A two-stage design was used, with days representing the first stage. Within each day, effort was estimated using angler counts; harvest per unit effort (HPUE), and catch per unit effort (CPUE) were estimated from angler interviews. The fishing day was defined as 16 hours in duration (0700-2300) and was stratified into three daily time strata (referred to as periods): (A) 0700-1159, (B) 1200-1659, and (C) 1700-2300 (past observations indicate that the angler effort between the hours of 2300 to 0700 is insignificant). The A period was sampled every fourth day and the B and C periods every third day.

This design resulted in 10 samples in period A and 12 each in periods B and C. Once a period was chosen, the entire period was sampled. Three angler counts were made systematically in each sampled period, such that the first count time was chosen randomly from the first five 20-minute periods and the next two counts taken at 1 hour and 40 minute intervals. Interviews were collected over the remainder of the period for a total of 4 hours in each sample unit.

The following equations were used to obtain catch and harvest estimates, along with their variances, for each stratum. The catch and harvest were estimated for each sampled period within a stratum, and estimated sample period mean catch (or harvest) was expanded over all sample periods in the stratum. The sample period catch (or harvest) was estimated by expanding estimated CPUE (or HPUE) by estimated effort (in angler-hours).

The first step in estimating the catch of Dolly Varden involved estimating the catch per unit effort (CPUE) for expansion purposes:

$$\begin{aligned} \text{CPUE}_{hi j}^* &= \text{the } j\text{th jackknifed estimate of CPUE;} \\ &= \frac{\sum_{\substack{k=1 \\ k \neq j}}^{m_{hi}} c_{hik}}{\sum_{\substack{k=1 \\ k \neq j}}^{m_{hi}} e_{hik}} \end{aligned} \quad [2]$$

where:

- h = subscript denoting stratum (period A, B, or C);
- i = subscript denoting day sampled;
- j & k = subscripts denoting the angler interviewed;
- m_{hi} = number of anglers interviewed during day i within stratum h ;
- c_{hik} = number of Dolly Varden caught by the k th angler interviewed during day i within stratum h ; and
- e_{hik} = number of hours fished by the k th angler interviewed during day i within stratum h .

Next, the mean jackknifed CPUE over all anglers interviewed in each sample was obtained:

$$\overline{\text{CPUE}_{hi}}^* = \frac{1}{m_{hi}} \sum_{j=1}^{m_{hi}} \text{CPUE}_{hi j}^* \quad [3]$$

A bias correction was performed (Efron 1982):

$$\overline{\text{CPUE}_{hi}}^{*\dagger} = m_{hi}(\overline{\text{CPUE}_{hi}}^* - \overline{\text{CPUE}_{hi}}^*) + \overline{\text{CPUE}_{hi}}^* \quad [4]$$

where:

$$\begin{aligned} \overline{\text{CPUE}}_{hi} &= \text{the "standard" mean CPUE (without jackknifing);} \\ &= \frac{\sum_{j=1}^{m_{hi}} c_{hij}}{\sum_{j=1}^{m_{hi}} e_{hij}} \quad [5] \end{aligned}$$

Next, the bias-corrected mean jackknifed CPUE's were expanded by the estimated sample effort to obtain the estimated catch in each sample:

$$\hat{C}_{hi} = \hat{E}_{hi} \overline{\text{CPUE}}_{hi}^* \quad [6]$$

where:

$$\begin{aligned} \hat{E}_{hi} &= \text{estimated angler effort expended by all anglers fishing during the } i\text{th sampled period, obtained as follows:} \\ &= H_{hi} \bar{x}_{hi} \quad [7] \end{aligned}$$

where:

$$\begin{aligned} H_{hi} &= \text{number of hours during each day within sample unit } i; \\ \bar{x}_{hi} &= \text{mean angler count during the } i\text{th sample within stratum } h; \\ &= \frac{1}{r_{hi}} \sum_{o=1}^{r_{hi}} x_{hio} \quad [8] \end{aligned}$$

where:

$$\begin{aligned} o &= \text{subscript denoting the count conducted within sample } i \text{ and stratum } h; \\ r_{hi} &= \text{number of angler counts conducted within sample } i \text{ and stratum } h; \text{ and} \\ x_{hio} &= \text{the number of anglers counted (fishing) during count } o \text{ within sample } i \text{ and stratum } h. \end{aligned}$$

Then the mean estimated catch was obtained over all samples within stratum h :

$$\hat{\bar{C}}_h = \frac{1}{d_h} \sum_{i=1}^{d_h} \hat{C}_{hi} \quad [9]$$

where:

d_h = the number of days sampled (day = sampling unit) in stratum h .

The overall stratum catch estimate was then obtained by expanding for the number of days in each stratum:

$$\hat{C}_h = D_h \hat{\bar{C}}_h \quad [10]$$

where:

D_h = total number of days in stratum h .

Finally, the total catch over all strata was obtained by summing the appropriate catch estimates:

$$\hat{C} = \sum_{h=1}^L \hat{C}_h \quad [11]$$

where:

L = total number of strata in the fishery survey (3).

The estimated variance for the stratum estimates of catch were obtained as follows (essentially the variance of a total estimated in a stratified two-stage sampling design as described by Cochran 1977):

$$\hat{V}[\hat{C}_h] = [(1 - f_{1h}) D_h^2 S_{1h}^2 / d_h] + [D_h \sum_{i=1}^{d_h} \hat{V}[\hat{C}_{hi}] / d_h] \quad [12]$$

where:

f_{1h} = sampling fraction for days;

= d_h / D_h , and [13]

$$S_{1h}^2 = \frac{\sum_{i=2}^{d_h} (\hat{C}_{hi} - \bar{\hat{C}}_h)^2}{(d_h - 1)} \quad [14]$$

$$\begin{aligned} \hat{V}[C_{hi}] &= \text{estimated variance of the sample estimate of catch, obtained} \\ &\text{by the formula for the variance of a product of random} \\ &\text{variables as proposed by Goodman (1960);} \\ &= \hat{E}_{hi}^2 s_{2hi}^* + (\overline{CPUE_{hi}}^*)^2 \hat{V}[E_{hi}] - s_{2hi}^* \hat{E}_{hi} \hat{V}[E_{hi}] \end{aligned} \quad [15]$$

where:

$$s_{2hi}^* = \text{the jackknife estimate of the variance of the estimated sample CPUE as described by Efron (1982);}$$

$$\frac{(m_{hi} - 1)}{m_{hi}} \sum_{j=1}^{m_{hi}} (CPUE_{hi,j}^* - \overline{CPUE_{hi}}^*)^2 \quad [16]$$

$$\hat{V}[E_{hi}] = \text{the estimated variance of estimated sample angler effort, obtained by expanding the variance of the counts (as obtained by the formula of systematic sampling described by Wolter 1985) by the square of the expansion factor (and then divided by the sample size):}$$

$$= \frac{H_h^2}{r_{hi}} \frac{\sum_{o=2}^{r_{hi}} (x_{hio} - x_{hi(o-1)})^2}{2 (r_{hi} - 1)} \quad [17]$$

The overall variance for all strata was obtained by summing the variances for each strata:

$$\hat{V}[C] = \sum_{h=1}^L \hat{V}[C_h] \quad [18]$$

Harvest estimates were obtained similarly by replacing the appropriate harvest statistics in place of the catch statistics in the above equations.

Effort was estimated similarly by expanding a mean sample effort (E_{hi}) over all days available, and the variance was estimated by substituting sample effort in place of catch.

The assumptions of this estimator are:

1. CPUE and HPUE of interviewed anglers are representative of the CPUE and HPUE of all anglers during the sample period.
2. There is no significant fishing effort or catch taking place during times outside of the defined fishing day.

Spawning Ground Surveys

Spawning ground surveys were conducted at the following sites; American River, Olds River, Buskin River mainstem and below the lake outlet, Buskin Lake near the outlet and the northwest end, and at Pillar Creek (in Monashka Bay) from 6 October to 11 October. Due to flood conditions it was impossible to complete the census on the Olds River. Single year Petersen and Schnabel mark-recapture experiments were used to determine populations of spawning Dolly Varden in the American River and northwest end of Buskin Lake. The other sites mentioned were surveyed for the presence of spawning Dolly Varden; no population estimates were attempted.

Two samples were taken in the American River and three samples were taken in Buskin Lake. The American River was divided into two sublocations to test for equal mixing of marked and unmarked fish between sampling events. One day was allowed at the American for mixing of marked and unmarked fish. A 50-foot beach seine was used to capture the Dolly Varden at the American, and a 100-foot seine was used in Buskin Lake. All fish captured were tagged with numbered green Floy anchor tags, measured for fork length, and examined for adipose clips.

The following assumptions must be met in order to achieve unbiased estimates of a closed population (Ricker 1975):

1. marked fish suffer the same mortality as the unmarked fish;
2. marked fish are equally vulnerable to capture as unmarked fish;
3. marked fish do not lose their mark;
4. marked fish become randomly mixed with the unmarked fish;
5. all marks are recognized and reported on recovery; and
6. there is negligible recruitment to the catchable population.

Statistical tests on the assumptions established validity to the Petersen estimation procedure. We have no evidence that marking Dolly Varden with anchor tags caused changes in mortality or behavior to affect assumptions 1 and 2. Recruitment into the American River population in October is considered negligible and emigration, if any, is assumed to be equal between marked and unmarked fish (assumption 6).

To test for equal mixing between marked and unmarked fish for the American River, a contingency table analysis was used. The test compared the ratio of marked to unmarked fish at each sublocation in event 2.

Kolmogorov-Smirnov (K-S) two-sample tests were used to determine if the different sizes of fish had equal probability of capture at the American River. The lengths of fish from event 1 were compared to the lengths of fish recaptured in event 2. Likewise, the fish in event 1 were compared to all the fish in event 2 (Figure 4).

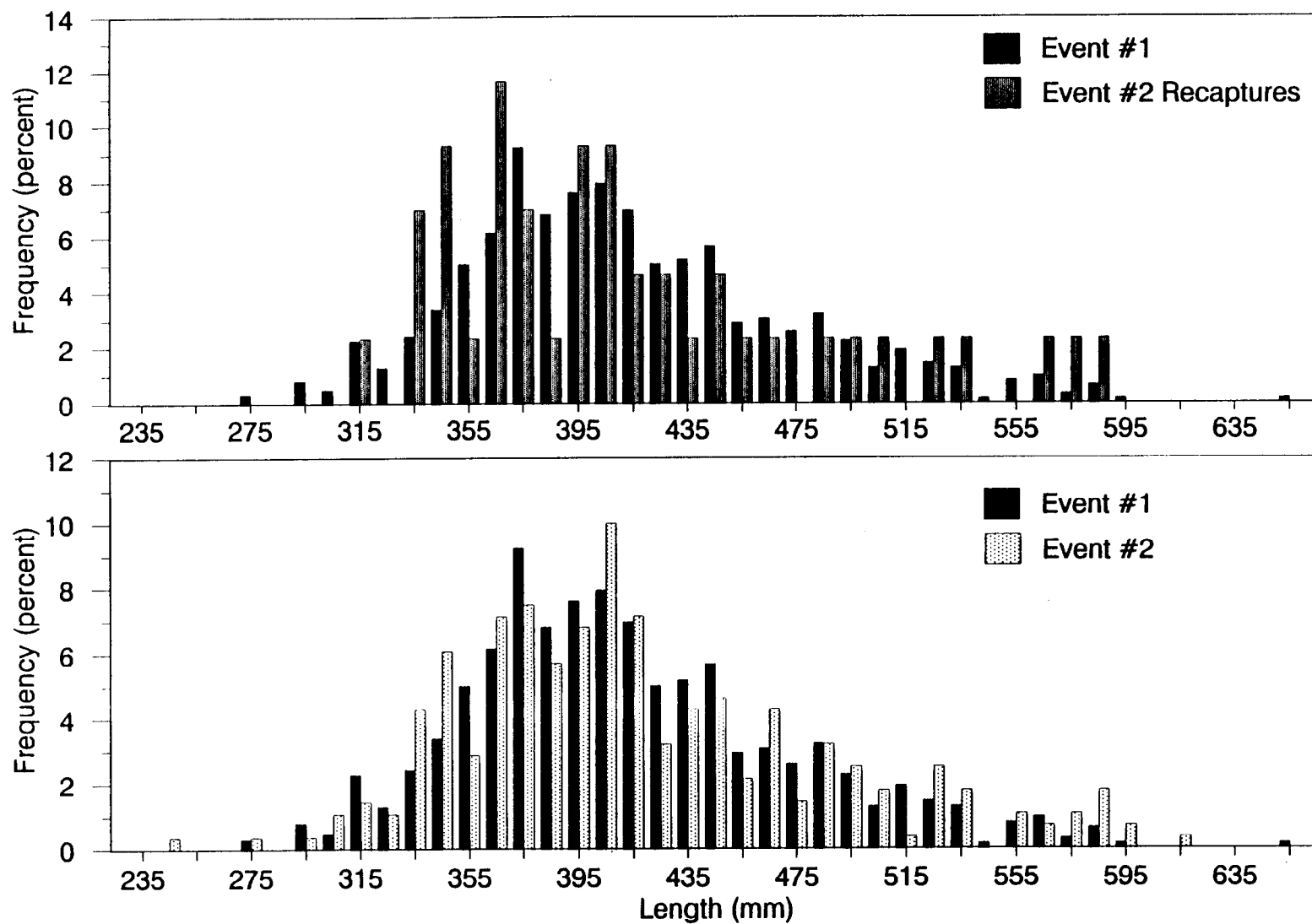


Figure 4. Length frequencies of Dolly Varden used to test size selectivity in event 1 and 2 of the population estimate at the American River, October 1990.

The abundance of the American River population could be estimated if the above conditions were met using the Chapman modification of the Petersen estimate (Ricker 1975):

$$N = \frac{(M+1)(C+1)}{(R+1)} - 1, \quad [19]$$

where N = estimated population size; M = marked fish at large; C = number of fish caught; and R = number of recaptures in catch. With variance:

$$\text{var}(N) = \frac{N^2(C-R)}{(C+1)(R+2)} \quad [20]$$

An abundance estimate for the northwest end of Buskin Lake was obtained using the Chapman modification of the Schnabel estimate (Ricker 1975):

$$N = \frac{\Sigma(C_t M_t)}{R+1} \quad [21]$$

where c_t = the number of fish caught on day t; m_t = the total number of marked fish at large at the start of the t^{th} day, and R = the total number of recaptures during the experiment. Confidence intervals (95%) were calculated using R as a Poisson variable (Appendix II, Ricker 1975).

RESULTS

Dolly Varden Census

During emigration there were 77 captures of fish that were known to have passed through the weir twice. The weir count, adjusted for these duplicate captures, was 90,600 (Appendix B1).

Length Composition

Larger Dolly Varden emigrated through the weir in the early weeks while smaller fish passed through in higher numbers later (Figure 5). Weeks 7 and 8 reflect the size of Dolly Varden after the Vexar was removed from the weir, therefore, these data will not be included in the length frequency discussion. Also, week 1 was not included because the sample size was only 14. A significant difference was found in the distribution of length classes among weeks 2-6 ($X^2 = 824.813$ and $P < 0.001$, Table 1). A weighted overall length frequency was calculated taking into consideration the weir counts and number of fish measured in each length category (Figure 6). I estimated length at full recruitment to the weir to be 210 mm. This corresponded to the largest length at which a fish would pass through the Vexar, 207 mm.

During immigration, length measurements were taken for 3 weeks (16 July to 5 August). More fish over 500 mm were measured in week 3 than in the two previous weeks (Figure 7).

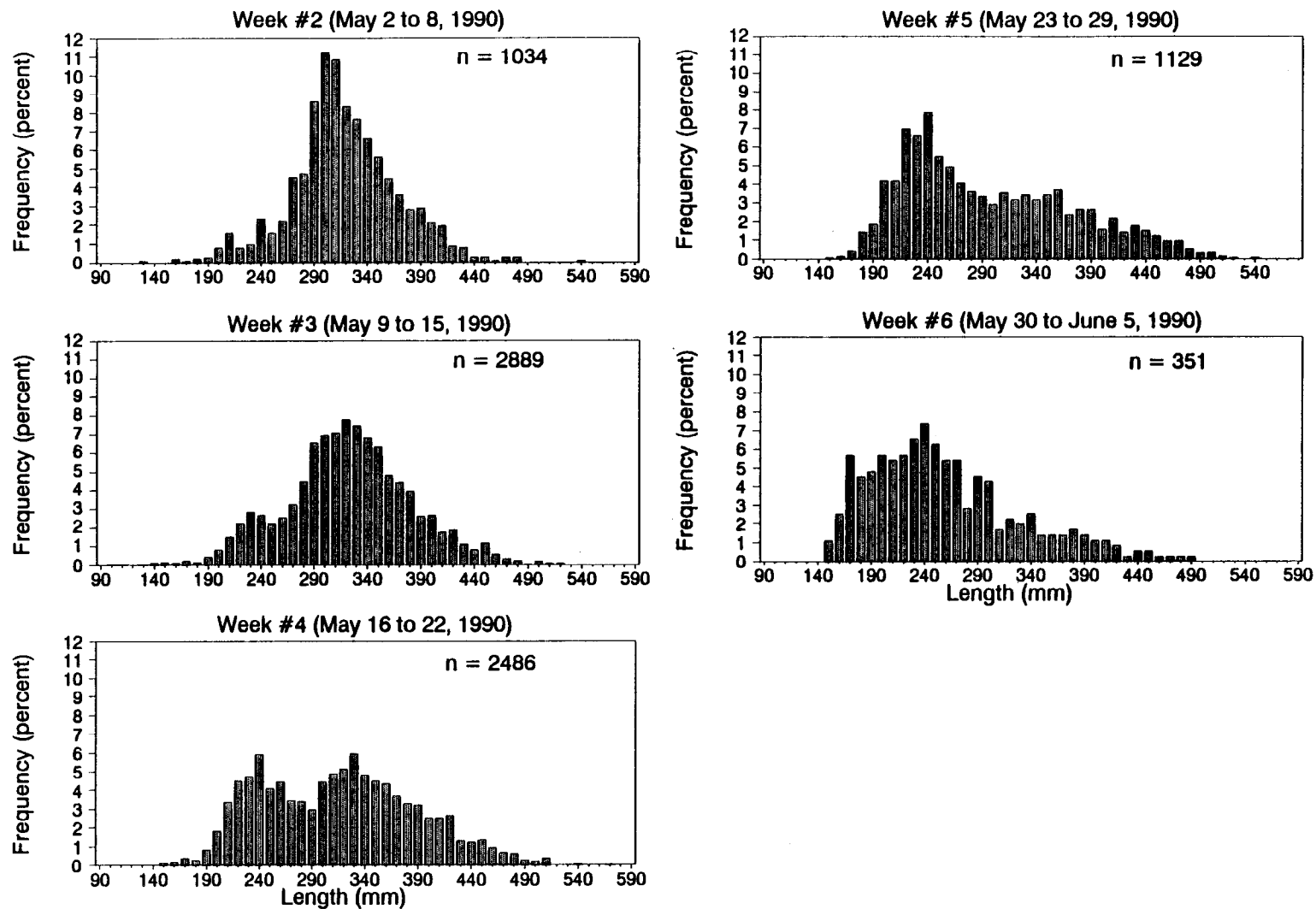


Figure 5. Length frequencies for emigrating Buskin River Dolly Varden for weeks 2 through 6, 1990.

Table 1. Counts of emigrating Dolly Varden by length group and week at the Buskin River weir in spring of 1990.

Week	Length (mm)				
	0-250	251-300	301-350	351-400	401-600
2	84	263	442	182	62
3	368	622	1035	588	277
4	604	460	631	452	339
5	413	229	189	154	143
6	184	85	40	25	17

Chi-square value = 824.813 df = 16 P < 0.001

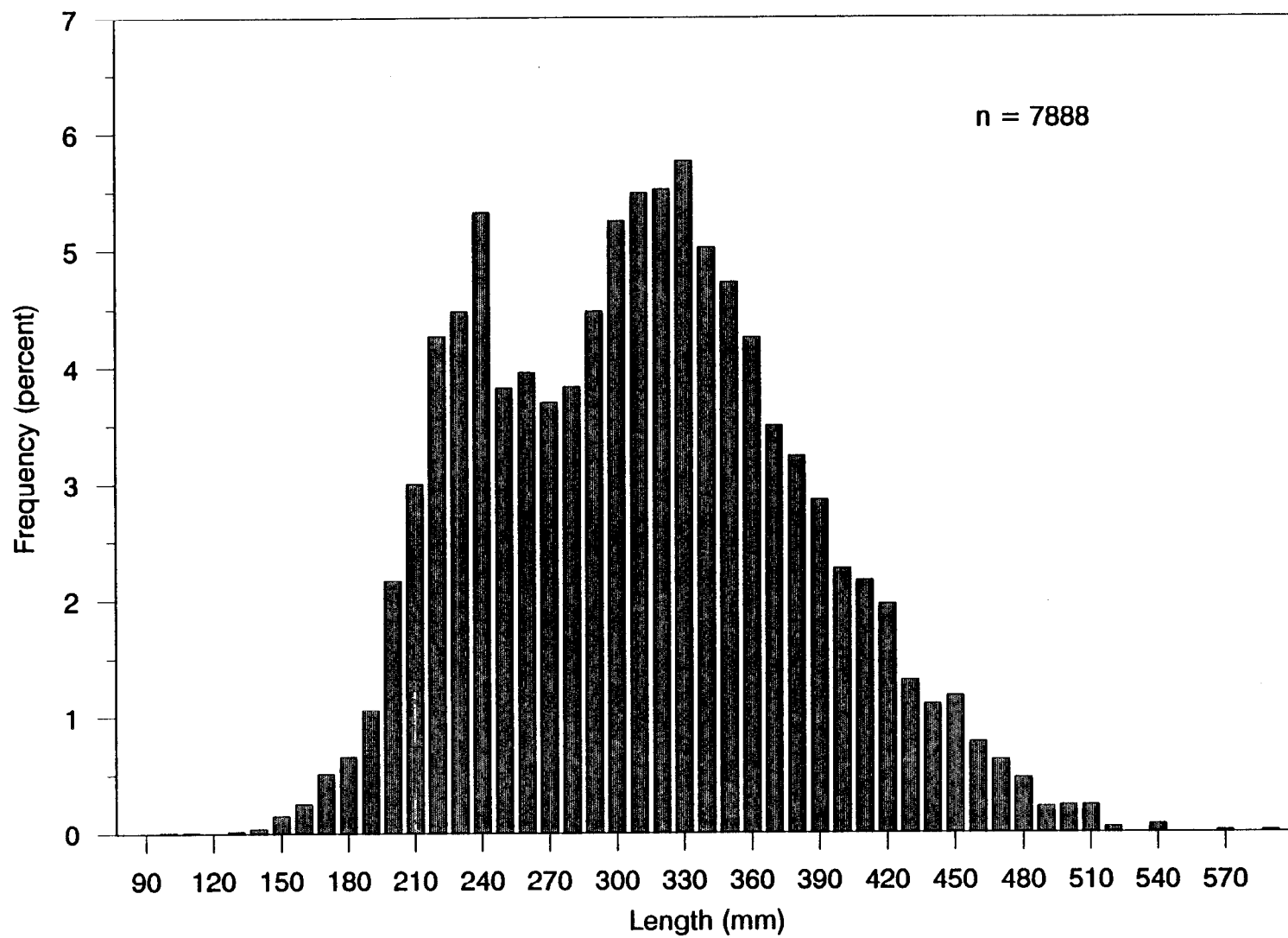


Figure 6. Weighted length frequency for emigrating Buskin River Dolly Varden.

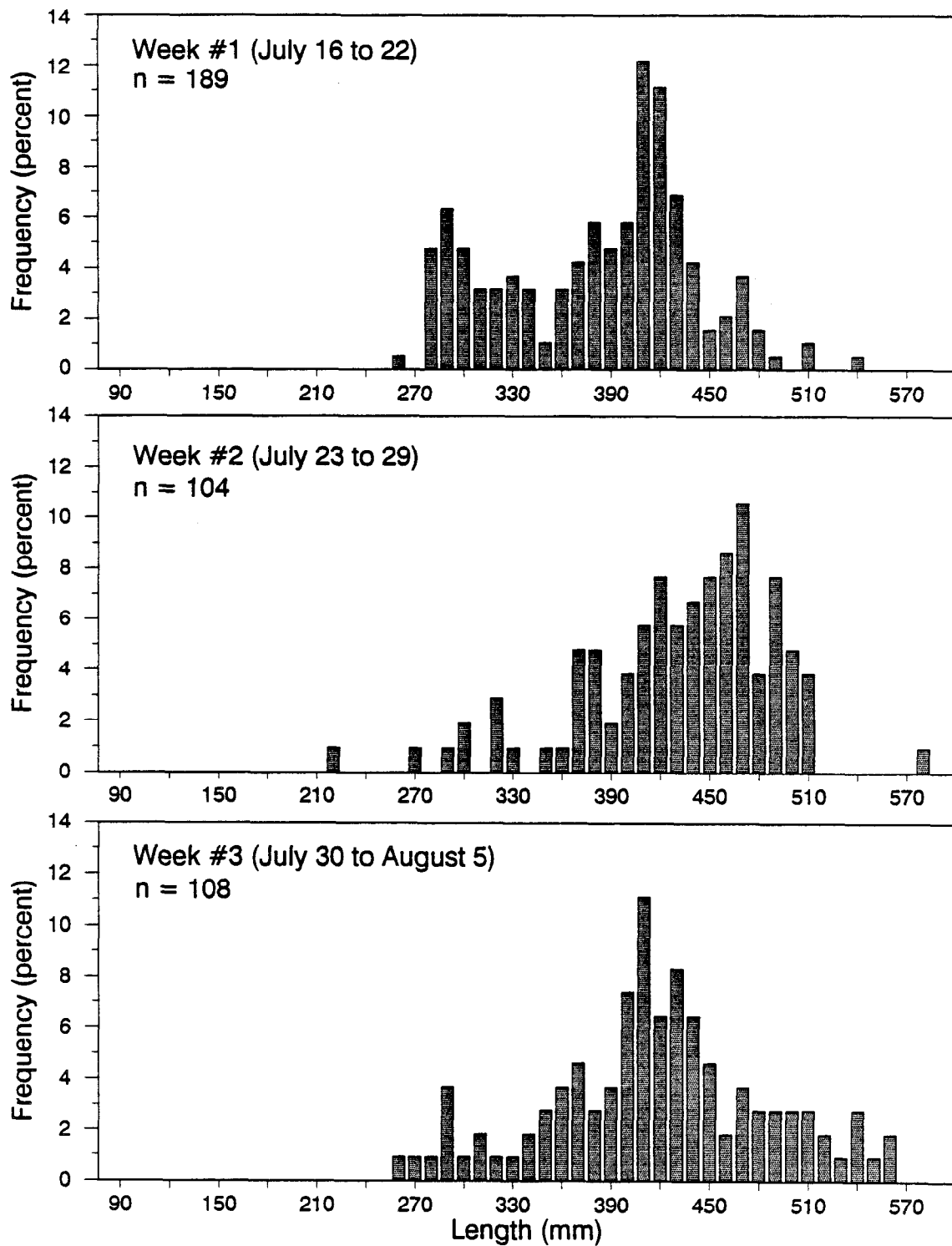


Figure 7. Length frequencies for immigrating Buskin River Dolly Varden for 16 July to 5 August 1990.

Tag Returns

During 1984-1990, a total of 46,779 Dolly Varden were tagged from the Chiniak Bay, Ugak Bay, and Afognak Island areas combined (Table 2). Between 25 April and 14 June 1990, 7,492 Dolly Varden were tagged. A total of 22,815 Dolly Varden were examined for tags. For the most part, fish were tagged in proportion to abundance (Figure 8) and in relation to length distribution. Recaptures totaled 1,527 fish (Table 3).

Relative Maturity

Results from the summer maturity sample from the Buskin River indicated that 48.2% (SE = 4.8) of the females were mature (State II). When comparing length and maturity state, mature females were usually larger than 400 mm while the immature State I fish were mostly below 350 mm. State V or developing immature Dolly Varden range across all size ranges but are more likely to be less than 350 mm (Table 4). The average length of State II fish from the July sample in the Buskin River was 434 mm (Table 5). The average length of fish found on the spawning grounds at the northwest end of Buskin Lake was 428 mm. From sampling in past years, it is apparent that tens of thousands of Dolly Varden enter the Buskin River in late summer (Sonnichsen 1990). A high percentage of these fish are sexually mature, indicating that the Buskin River system has a significant spawning population.

During the fall spawning ground survey, a large number of Dolly Varden were present in Buskin Lake near the outlet. A maturity sample of these fish indicated that 71% (SE = 5.9) of the females were in State V, possibly preparing to spawn next year.

Creel Survey

The total estimated effort from 23 April through 25 May was 4,268 angler hours; the total catch was 6,355 and total harvest was 2,362 Dolly Varden (Table 6). This year's harvest is a decline from last year's harvest of 5,761 and is the lowest point estimate since the Buskin River creel survey's inception in 1984. Estimates between 1989 and 1990 are not significantly different from each other because confidence intervals for 1990 effort, harvest and catch overlapped with intervals from 1989 effort, harvest, and catch (Sonnichsen 1990). Estimates of effort, catch, and harvest from each sample are given in Appendix B2. The variability among days sampled accounts for the majority of the variance of the final estimates (Table 6).

Statistics for interviewed anglers showed that residents dominated the Buskin River sport fishery (Table 7).

As in past years, the majority of the Dolly Varden sampled during the creel survey were less than 350 mm (Figure 9). When the length frequency of the sport caught fish was compared to the frequencies of Dolly Varden passing through the weir at the same time period, chi-square tests showed there were significant differences between them ($\chi^2 = 38.372$, $df = 4$, $P < 0.001$, Figure 10). The large sample sizes of weir-caught fish may cause statistically significant differences between the two comparisons even though the differences may have no practical significance.

Table 2. Tagging summary, Kodiak Dolly Varden 1984-October 1990.

Year	Site	Dates	Tag Color	Tag Numbers	Number Tagged
1984	Buskin River	17 May-17 Jun	Yellow	1 - 474	472
1985	Buskin River	27 Apr-17 Jun	Yellow Green	475 - 1800 651 - 743	1318
1986	Buskin River	24 Apr-16 May	Pink	2001 - 6000	3986
	Buskin River	29-30 Oct	Red	1 - 575	461
	Salonie Creek	14 Aug	Orange	2501 - 2550	97
		14 Sept	Orange	2851 - 2897	
	American River	7-12 Aug	Orange	1403 - 1962	560
	Olds River	5-6 Aug	Orange	1 - 1402	1402
	Roslyn River	13 Aug	Orange	2001 - 2030	30
	Pasagshak River	15 & 19 Aug	White	1 - 1000	1596
		11-12 Sept	White	18235 - 19993 ^a	
	Afognak River	4-5 Sept	Blue	1 - 1000	1476
			Blue	20325 - 20803	
1987	Buskin River	20-30 May	Yellow Orange Pink	1801 - 4000 1963 - 3000 ^a 4001 - 5000	4051
	Buskin River	26-27 Aug	Pink	6001 - 7000	1000
	American River	20 & 22 Aug	Orange	4501 - 6000	1500
	Olds River	11-12 Aug	Orange	3001 - 4500	1498
	Pasagshak River	24-25 Aug	White	1001 - 2000	1000
	Saltery Creek	14-15 May	Green	3001 - 5000	2000
	Afognak River	4-5 Sept	Blue	1001 - 2000	1000
1988	Buskin River	20-25 Oct	Red Pink Green	1001 - 2000 7001 - 8000 124001 - 125000	2998
	American River	18-22 Oct	Pink w/ Black	5001 - 6000 ^a	650
	Olds River	26-31 Oct	Green	125001 - 125267	267

-continued-

Table 2. (Page 2 of 2).

Year	Site	Dates	Tag Color	Tag Numbers	Number Tagged
1989	Buskin River	3 May-1 Jun	Green	125268 - 129308 ^a	4012
			Green	155737 - 156500	4433
	Buskin River	Oct	Green	156550 - 157000	
			Green	157347 - 157999	
			Green	162457 - 164280 ^a	
			Green	164801 - 165375	
			Green	165501 - 165725 ^a	
			Green	157001 - 157346	801
	Olds River	Oct	Green	162001 - 162456	
			Green	155001 - 155736	784
			Green	156501 - 156550	
1990	Buskin Lake	30 Apr-14 Jun	Green	190001 - 195000	7492
			Green	211001 - 213499	
	American River	6 Oct-8 Oct	Green	213500 - 214045	546
			Green	214610 - 214821	212
	Olds River	7 Oct	Green	214046	1
			Green	214601 - 214609	9
	Buskin Lake-NW	9 Oct-11 Oct	Green	215085 - 215731	646
	Buskin Lake-Out	9 Oct	Green	214826 - 215084	259
	Buskin River	9 Oct	Green	214047 - 214125	79
	Pillar Creek	10 Oct	Green	214126 - 214268	143
Total Tagged					46779

^a Missing blocks of tags in this sequence.

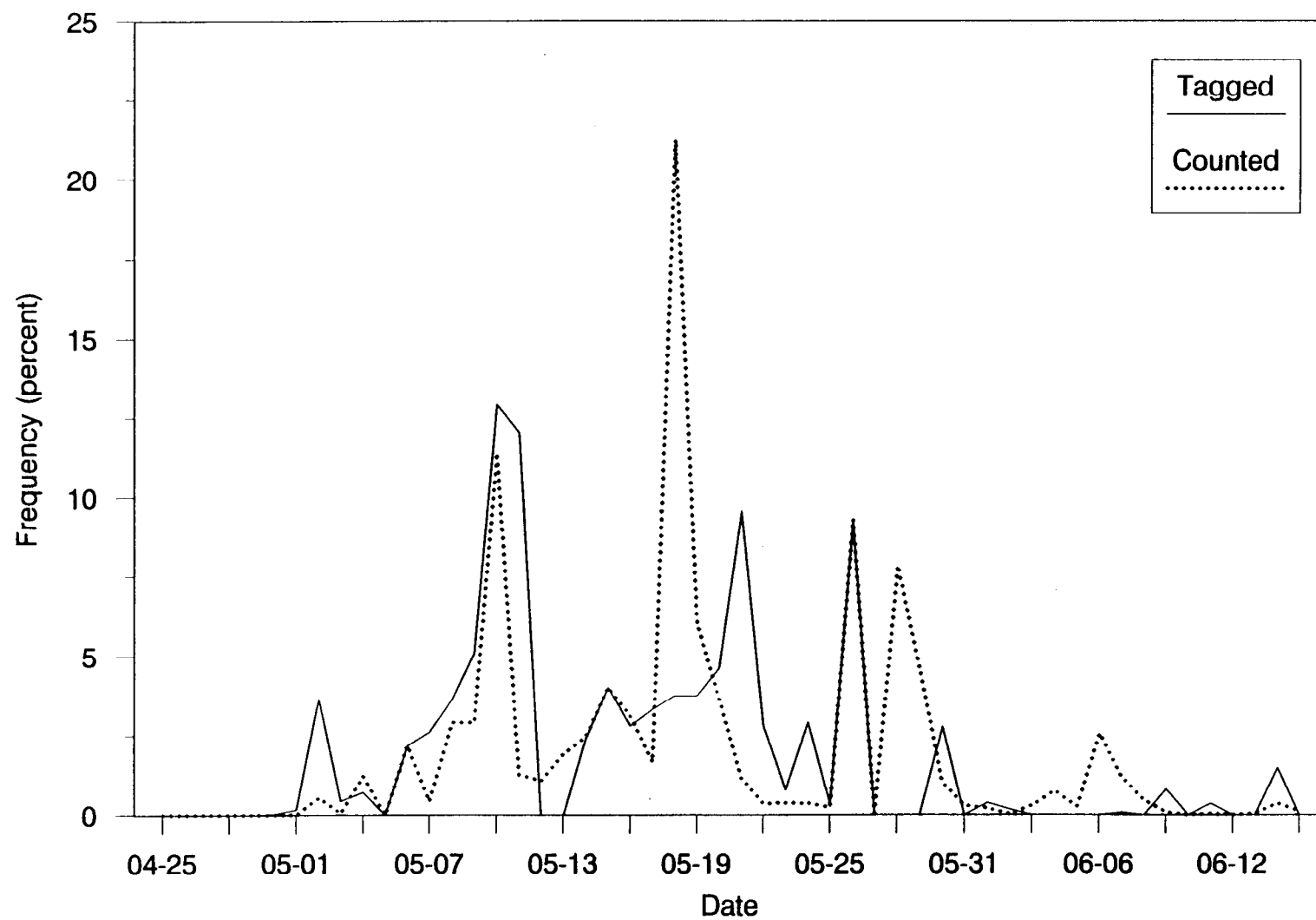


Figure 8. Percent of total daily emigrating Dolly Varden weir count and daily tag count, spring 1990.

Table 3. Dolly Varden tag recoveries by release location for all tagging sites for 1988-1990.

Recaptures (# unique examined)	Releases (# unique releases with tags)								
	1988 Fall American (709)	1988 Fall Olds (283)	1988 Fall Buskin (3,006)	1989 Spring Buskin (4,476)	1989 Fall American (893)	1989 Fall Olds (833)	1989 Fall Buskin (4,484)	1990 Spring Buskin Weir (8,450)	1990 Summer Buskin Weir (21)
1989 Spring Buskin Weir (10,126)	50	21	105	-	-	-	-	-	-
1989 Fall American (896)	38	0	3	50	-	0	0	-	-
1989 Fall Olds (836)	1	5	9	21	0	-	0	-	-
1989 Fall Buskin (4,503)	0	0	30	12	0	0	-	-	-
1990 Spring Buskin Weir (22,815)	16	10	161	221	57	69	378	-	-
1990 Spring Buskin Creel (372)	0	0	4	4	0	0	4	19	-
1990 Summer Buskin Weir (403)	0	0	2	3	0	0	4	11	-
1990 Fall American (897)	2	0	6	8	34	0	7	33	0
1990 Fall Olds (12)	0	0	0	0	0	1	0	0	0
1990 Fall Buskin Lake northwest end (725)	0	0	4	14	2	0	4	52	2
1990 Fall Buskin River mainstem (87)	0	0	2	0	0	1	1	5	0
1990 Fall Buskin River nr lk outlet (276)	0	0	0	0	0	0	3	1	0
1990 Fall Buskin Lake near outlet (391)	0	0	0	0	1	0	20	16	0

Table 4. Percent of immigrating female Dolly Varden in each length class by maturity state at the Buskin River weir for 18 and 19 July 1990. Sample size for females = 110.

Maturity State	n	Length (mm)		
		< 350 n = 41	350 - 400 n = 16	> 400 n = 53
I	26	58.5%	12.5%	0.0%
II	53	2.4%	25.0%	90.6%
III	0	0.0%	0.0%	0.0%
IV	0	0.0%	0.0%	0.0%
V	31	39.0%	62.5%	9.4%

Table 5. Average lengths and ranges by maturity state of Dolly Varden from the Buskin River system and the American River, 1990.

Location	Date	Maturity State	Average Length (mm)	Length Range (mm)	Sample Size
Buskin River	7/18 to 7/19	I	306	277 - 391	26
		V	350	258 - 431	31
		II	434	330 - 545	53
Buskin Lake outlet	10/9	I	273	239 - 304	16
		V	305	259 - 366	43
		III	355	349 - 361	2
Buskin Lake northwest end	10/9 to 10/11	III ^a	428	275 - 593	723
American River	10/6 and 10/8	III ^a	405	232 - 648	897

^a Fish on spawning grounds assumed to be state III.

Table 6. Buskin River effort, catch, and harvest estimates, 23 April through 25 May 1990.

	Period	Number of Days		Mean	Total	S_{1h}^2	Variance Components		Total Variance	Relative Precision ^a
		Total	Sampled				among days	within days		
Effort	A	33	9	23	758	423	37,203	2,276	39,479	51
	B	33	11	58	1,930	2,876	189,803	8,000	197,803	45
	C	33	11	48	1,580	793	52,363	7,625	59,988	30
	TOTAL				4,268				297,271	25
Dolly Varden Catch	A	33	8	59	1,957	5,369	553,679	54,667	608,345	78
	B	33	11	86	2,840	6,174	407,514	64,580	472,093	47
	C	33	11	47	1,558	2,636	173,967	26,557	200,524	56
	TOTAL				6,355				1,280,962	35
Dolly Varden Harvest	A	33	8	29	948	1,228	126,621	20,673	147,294	79
	B	33	11	28	940	1,310	86,469	19,478	105,947	68
	C	33	11	14	473	397	26,235	3,924	30,159	72
	TOTAL				2,362				283,400	44

^a Relative precision of 95% confidence interval.

Table 7. Statistics for interviewed anglers, Buskin River creel survey,
23 April through 25 May 1990.

Period	Number Interviewed	DV Caught	DV Harvested	Mean CPUE	Mean HPUE	Residents ^a	Non- Residents ^a
A	60	186	98	2.3073	1.3952	50	4
B	166	437	130	1.7820	0.5568	153	12
C	293	345	116	0.8487	0.2697	265	27

^a Number of residents and nonresidents interviewed does not add up to the total interviewed because residency was not determined for some interviewed anglers.

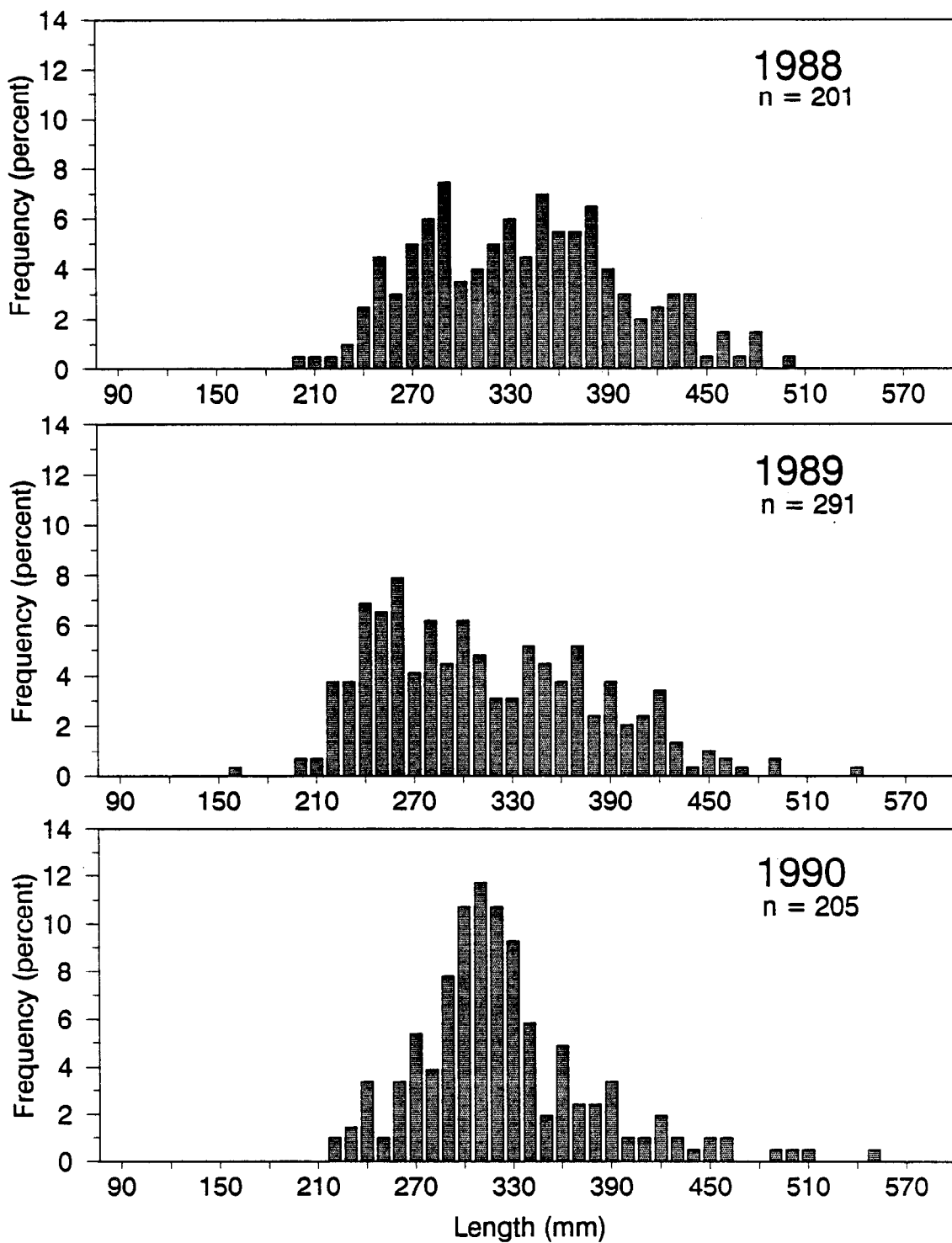


Figure 9. Comparison of 3 years of length frequencies of Buskin River creel caught Dolly Varden, 1988 to 1990.

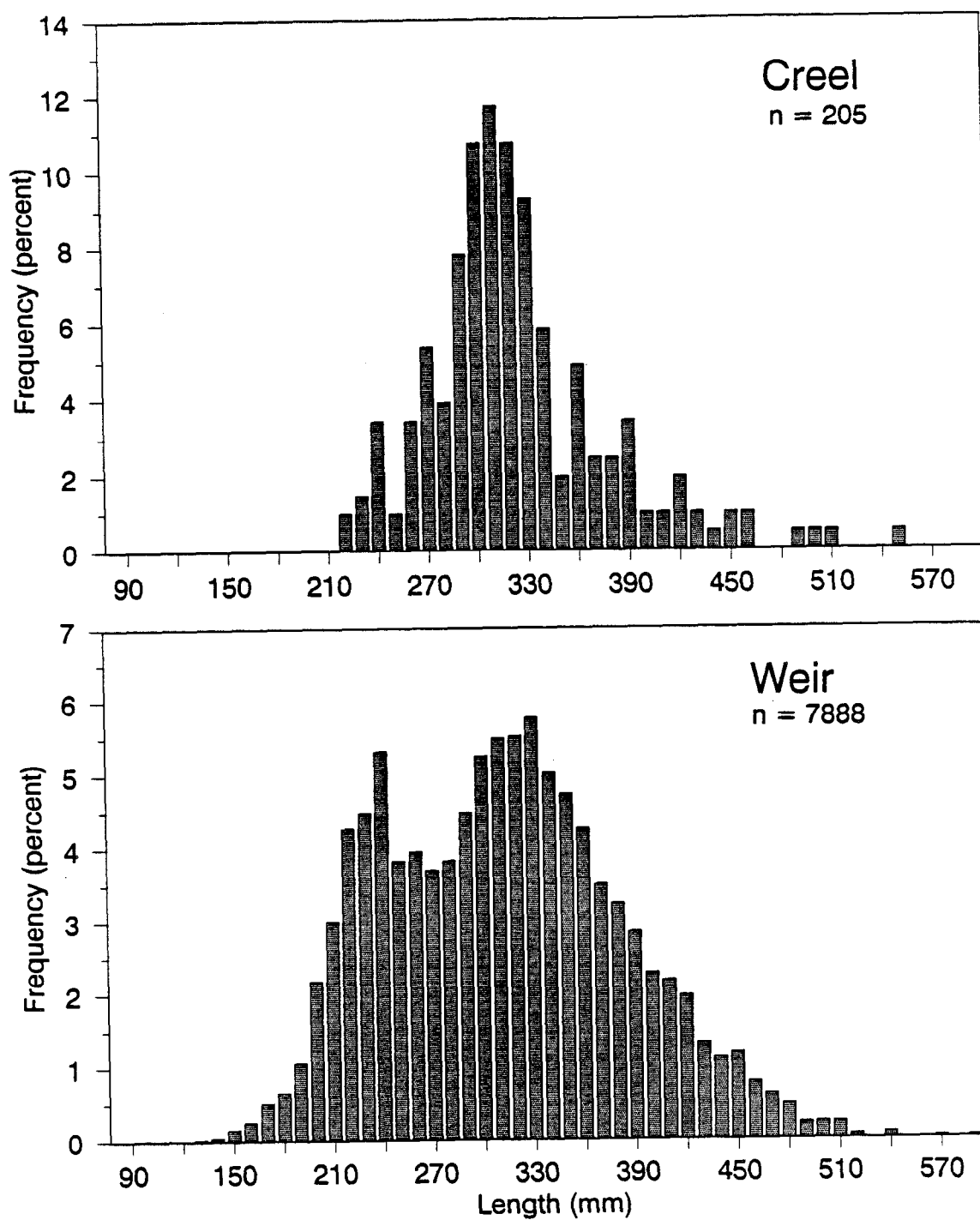


Figure 10. Comparison of length frequencies from 1990 creel and 1990 weir Buskin River Dolly Varden.

Spawning Ground Surveys

For all sites surveyed in October (Table 8), we were able to get a population estimate for the American River and Buskin Lake only. There was equal mixing of marked and unmarked fish between sublocations at the American River ($X^2 = 0.068$, $df = 1$, $0.75 > P > 0.90$, Table 9). At the American River there was no size selectivity between events from Kolmogorov-Smirnov test results (Table 10). There was size selectivity between events one and two at the northwest end of Buskin Lake but no selectivity between the other events (Table 10). The Petersen estimate for the American River was 3,947 Dolly Varden (SE = 540). This is consistent with the 1989 estimate of 4,125 fish (SE = 805, Sonnichsen 1990) and with the 1988 estimate of 3,048 fish (SE = 419, S. Sonnichsen, Alaska Department of Fish and Game, Anchorage, personal communication). An estimate was obtained for the northwest end of Buskin Lake but variance estimates are high due to the low number of recaptures from previous events (Table 11). The estimate for spawning adults in Buskin Lake was 19,289 fish (SE = 5,824). Despite the uncertainty of the estimate, we now know that there is a large number of spawning adults present in the Buskin River system that have not been documented previously.

Only 87 fish were found in the mainstem of the Buskin River. These consisted of adults with an average size of 385 mm. High numbers of small Dolly Varden were present in the upper section of the Buskin River near the lake outlet as was documented in 1989 (Sonnichsen 1990). A large number of Dolly Varden, averaging 299 mm, were also present in the lake near the outlet. Length frequencies for all four Buskin River system survey sites show significant differences in size at the different locations (Figure 11, Table 12).

Dolly Varden were captured and tagged at Pillar Creek to investigate the potential contribution of the fish to the Buskin Lake overwintering population. One hundred forty-three fish were tagged and released. Emigrations from Buskin Lake in future years will be monitored for the presence of these tags.

DISCUSSION

Prior to 1990, the stock structure model involved two main assumptions: all Dolly Varden from the Chiniak Bay area overwinter in Buskin Lake, and the American and Olds rivers were the major spawning streams for this "super-population." From results of the 1990 season, we have updated this model to include Buskin Lake as a significant spawning area. This conclusion was supported by the large percentage (42.8%) of mature females among the 1990 Buskin River immigrants; and by the significant number of large, apparently spawning, Dolly Varden present at the northwest end of Buskin Lake in October 1990.

From the total weir counts for the 1990 spring season, it was apparent that weir counts from previous years did not effectively census the entire population. In 1990, we counted 90,600 Dolly Varden greater than 210 mm (length at recruitment to the weir) and in 1989 the count was 30,320 Dolly Varden for fish greater than 300 mm (Sonnichsen 1990).

Table 8. Fall spawning ground survey counts of Dolly Varden in the Chiniak Bay area, October 1990.

Location Sampled	Date	Number Tagged	Number Recaptures	Number Unique Examined ^a
American River	10/6	546	69	617
	10/8	212	27	280
Olds River	10/7	10	1	12
Northwest end of Buskin Lake	10/9	51	2	53
	10/10	534	69	603
	10/11	62	7	69
Outlet of Buskin Lake	10/9	259	37	296
Buskin River mainstem	10/9	79	8	87
Buskin River near lake outlet	10/10	0	4	276
Pillar Creek	10/10	143	0	255

^a Including fish measured only.

Table 9. Comparison of number of marked fish in event 2 to number of unmarked fish in event 2 at sublocations within the American River during the 1990 population estimate.

	Sublocation	
	1	2
Marked	26	17
Unmarked	152	91

Chi-square = 0.068, df = 1, 0.50 < P < 0.75

Table 10. Results of Kolmogorov-Smirnov two-sample tests on assumptions of size selectivity in Petersen estimates for the American River and the northwest end of Buskin Lake, October 1990. Number of observations in parenthesis.

First Sample	Second Sample	D _{MAX}	P
<u>American River</u>			
Event #1 Releases (617)	Event #2 Releases (280)	.0461	.7762
Event #1 Releases (617)	Event #2 Recaptures (43)	.0772	.9634
<u>Buskin Lake - northwest end</u>			
Event #1 (53)	Event #2 (603)	.2789	.0006 ^a
Event #2 (603)	Event #3 (68)	.1586	.0835
Event #1 (53)	Event #3 (68)	.1859	.2156

^a Significantly different at $\alpha = 0.05$.

Table 11. Release and recapture data for Petersen estimates for the American River and the northwest end of Buskin Lake, October 1990.

Location	Event	Released with a tag	Recaptures from previous events	Population Estimate	SE
American River	1	617	0	3,947	540.3
	2	280	43		
Buskin Lake - northwest end	1	53	0	19,289	5,824.5
	2	603	1		
	3	69	2		

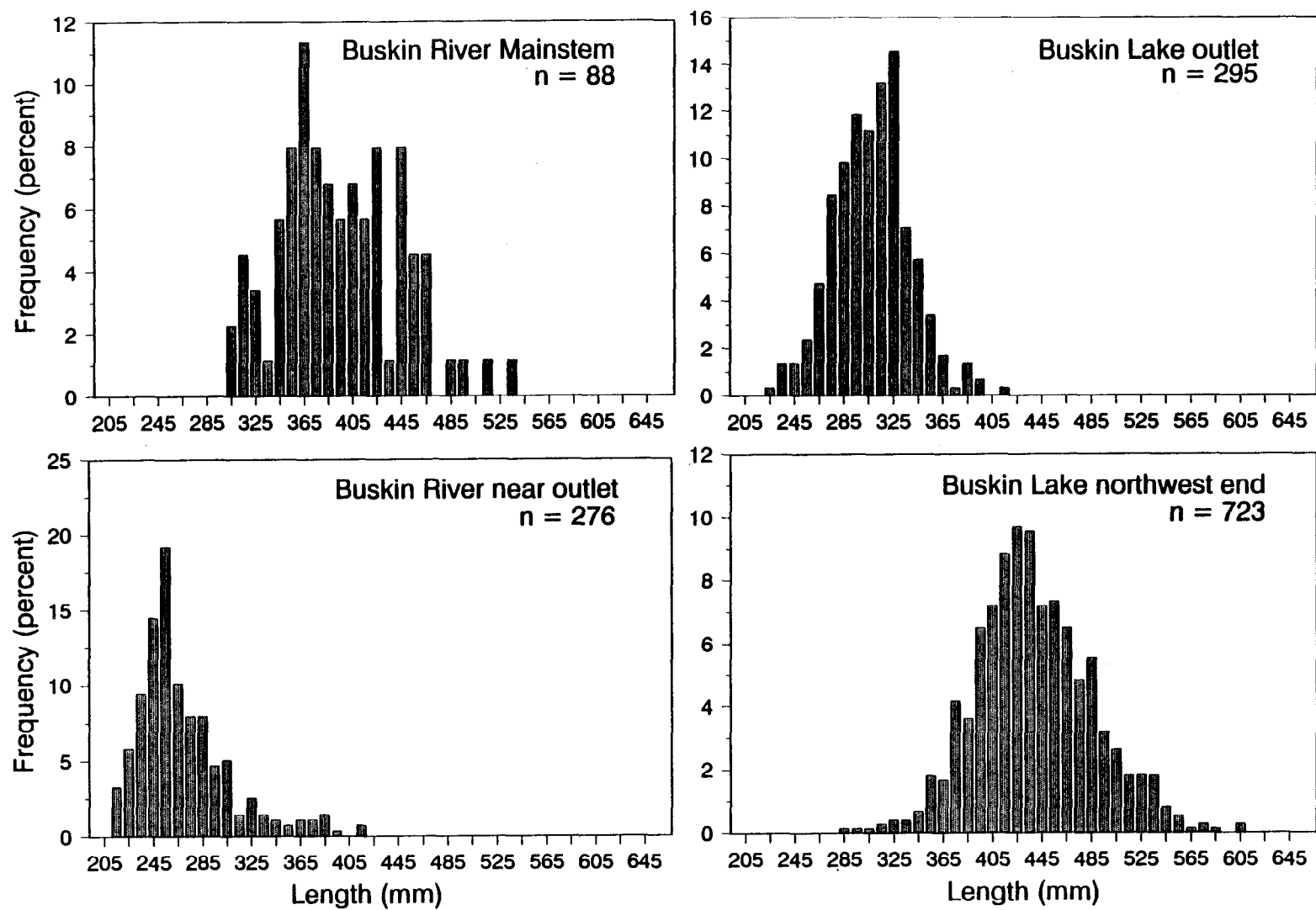


Figure 11. Length frequencies of Buskin River system Dolly Varden at four locations, October 1990.

Table 12. Results of Kolmogorov-Smirnov tests on length distributions for Buskin River system fall spawning ground surveys. Number of observations in parenthesis.

Location #1	Location #2	D _{MAX}	P
Buskin Lake - northwest end (723)	Buskin River - mainstem (88)	.3499	.0000 ^a
Buskin River - mainstem (88)	Buskin River - near lake outlet (276)	.8878	.0000 ^a
Buskin River - near lake outlet (276)	Buskin Lake - outlet (295)	.5229	.0000 ^a
Buskin Lake - northwest end (723)	Buskin River - near lake outlet (276)	.8990	.0000 ^a
Buskin Lake - northwest end (723)	Buskin Lake - outlet (295)	.8352	.0000 ^a
Buskin River - mainstem (88)	Buskin Lake - outlet (295)	.7095	.0000 ^a

^a Significantly different at $\alpha = 0.05$.

Temporal changes in length composition of the spring emigration have been documented in previous years (S. Sonnichsen, Alaska Department of Fish and Game, Anchorage, personal communication). During the 1990 spring season the same has held true, indicating that the larger fish leave earlier in the emigration.

Harvest of Dolly Varden by anglers has declined to the lowest point since 1984, but this change is not reflected in the weir counts. Changes in effort, catch, and harvest were not significantly different from 1989. The decline in harvest may be due to a concurrent decline in effort.

During the 1991 fall spawning ground survey, a more comprehensive analysis of the Buskin Lake spawning area should be conducted. This would include dividing the area into sublocations to test for equal mixing of marks and allowing a day between samples for mixing.

Future goals of this project are to obtain at least 3 years of tagging information at the present weir site to allow estimation of population abundance using the Jolly-Seber method (Jolly 1965, Seber 1965). Data from previous years can not be used in the Jolly-Seber estimate because the weir did not stop fish under 300 mm. If a stratified estimate of fish over 300 mm is desired, the 1989 data may be used, but none prior to that because fish were not tagged in the spring of 1988. Continuous data for the Dolly Varden emigration is needed for the Jolly-Seber method. Tag return data will also be useful in determining growth of Dolly Varden which will be analyzed at a future date.

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APPENDIX A

Appendix A. Data files used to produce this report.

Q0030LA0.DTA	- Buskin River weir emigration Dolly Varden tagging - 4/30/90 to 5/9/90.
Q0030LB0.DTA	- Buskin River weir emigration Dolly Varden tagging - 5/10/90 to 5/11/90.
Q0030LC0.DTA	- Buskin River weir emigration Dolly Varden tagging - 5/14/90 to 5/20/90.
Q0030LD0.DTA	- Buskin River weir emigration Dolly Varden tagging - 5/21/90 to 6/02/90.
Q0030LE0.DTA	- Buskin River weir emigration Dolly Varden recaptures - 5/2/90 to 5/15/90.
Q0030LF0.DTA	- Buskin River weir emigration Dolly Varden recaptures - 5/16/90 to 6/2/90.
Q0030LG0.DTA	- Buskin River creel survey recaptures - 5/23/90 to 5/29/90.
Q0030LH0.DTA	- Buskin River weir emigration Dolly Varden recaptures - 6/4/90 to 6/14/90.
Q0030LI0.DTA	- Buskin River weir emigration Dolly Varden tagging - 6/7/90 to 6/14/90.
Q0030LJ0.DTA	- Buskin River weir immigration Dolly Varden length samples - 7/27/90 to 8/1/90.
Q0030LK0.DTA	- Buskin River weir immigration Dolly Varden maturity lengths - 7/18/90 to 7/19/90.
Q0030LL0.DTA	- Buskin River mainstem Dolly Varden tagging - 10/9/90.
Q0030LM0.DTA	- Buskin River near lake outlet Dolly Varden length sample - 10/10/90.
Q0030CA0.DTA	- Buskin River creel survey angler count data.
Q0030IA0.DTA	- Buskin River creel survey angler interview data.
Q1140LA0.DTA	- American River population estimate, first event tagging - 10/6/90.

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Q1140LB0.DTA - American River population estimate, second event
tagging - 10/8/90.

Q122ALA0.DTA - Buskin Lake near outlet length sample and tagging
- 10/9/90.

Q122ALB0.DTA - Buskin Lake near outlet maturity length sample -
10/9/90.

Q122BLA0.DTA - Buskin Lake northwest end population estimate,
first event tagging - 10/9/90.

Q122BLB0.DTA - Buskin Lake northwest end population estimate,
second event tagging - 10/10/90.

Q122BLC0.DTA - Buskin Lake northwest end population estimate,
third event tagging - 10/11/90.

Q1630LA0.DTA - Olds River population estimate attempt, tagging -
10/7/90.

Q1670LA0.DTA - Pillar Creek tagging - 10/9/90.

These data files are all archived with Alaska Department of Fish
and Game, Division of Sport Fish, Research and Technical
Services Unit, 333 Raspberry Road, Anchorage, Alaska 99518-1599.
Contact Gail Heineman or Donna Buchholz (267-2369) for copies of
the files and descriptions of the file formats.

APPENDIX B

Appendix B1. Adjusted weir counts for Buskin River Dolly
Varden emigration, 1990.

Date	Adjusted Daily Weir Count	Adjusted Cumulative Weir Count	Date	Adjusted Daily Weir Count	Adjusted Cumulative Weir Count
23-Apr	0	0	20-May	3313	61525
24-Apr	0	0	21-May	1043	62568
25-Apr	1	1	22-May	329	62897
26-Apr	0	1	23-May	334	63231
27-Apr	10	11	24-May	315	63546
28-Apr	0	11	25-May	212	63758
29-Apr	7	18	26-May	8468	72226
30-Apr	2	20	27-May	40	72266
01-May	12	32	28-May	7140	79406
02-May	475	507	29-May	4162	83568
03-May	37	544	30-May	914	84482
04-May	1041	1585	31-May	269	84751
05-May	0	1585	01-Jun	200	84951
06-May	1963	3548	02-Jun	20	84971
07-May	388	3936	03-Jun	271	85242
08-May	2596	6532	04-Jun	687	85929
09-May	2616	9148	05-Jun	248	86177
10-May	10252	19400	06-Jun	2330	88507
11-May	1126	20526	07-Jun	1075	89582
12-May	976	21502	08-Jun	420	90002
13-May	1735	23237	09-Jun	69	90071
14-May	2204	25441	10-Jun	11	90082
15-May	3645	29086	11-Jun	32	90114
16-May	2829	31915	12-Jun	1	90115
17-May	1508	33423	13-Jun	54	90169
18-May	19317	52740	14-Jun	325	90494
19-May	5472	58212	15-Jun	106	90600

Appendix B2. Daily statistics for Buskin River Dolly Varden creel survey, 1990.

PERIOD	DATE	Number of Interviews	Total Effort	Variance Effort	CPUE	Variance CPUE	Total Catch	Variance Catch	HPUE	Variance HPUE	Harvest	Variance Harvest
A	900423	6	15	0	1.337	0.579	20	130	1.337	0.579	20	130
A	900427	8	27	83	0.844	0.164	22	162	0.192	0.019	5	15
A	900501	3	10	4	0.452	0.336	5	33	0.452	0.336	5	33
A	900505	10	63	302	3.040	1.509	193	8,387	1.395	0.675	88	3,090
A	900509	18	38	135	3.299	0.453	126	2,079	1.944	0.351	75	980
A	900513	9	38	83	2.823	1.296	108	2,461	0.973	0.493	37	763
A	900517	1	12	8	0.000	0.000	0	0	0.000	0.000	0	0
A	900521	5	2	2	0.000	0.000	0	0	0.000	0.000	0	0
A	900525		2	2								
B	900424	5	18	35	0.000	0.000	0	0	0.000	0.000	0	0
B	900428	28	137	167	1.437	0.198	196	4,018	0.602	0.070	82	1,363
B	900501	11	20	85	1.206	0.275	24	211	0.851	0.364	17	176
B	900504	17	55	19	2.375	0.278	131	941	0.435	0.068	24	208
B	900507	8	48	77	0.812	0.483	39	1,143	0.049	0.004	2	10
B	900510	15	42	60	3.076	2.198	128	4,255	0.817	0.140	34	275
B	900513	27	187	1,652	1.184	0.146	221	7,175	0.574	0.111	107	4,242
B	900516	13	37	352	0.764	0.191	28	395	0.000	0.000	0	0
B	900519	18	28	33	4.794	2.161	136	2,429	1.471	0.164	42	198
B	900522	7	48	83	0.480	0.306	23	708	0.080	0.008	4	20
B	900525	17	23	102	0.860	0.398	20	252	0.042	0.002	1	1
C	900424	16	58	777	0.484	0.039	28	284	0.101	0.004	6	18
C	900428	32	70	319	0.294	0.015	21	94	0.094	0.005	7	27
C	900501	31	40	42	0.951	0.145	38	263	0.226	0.010	9	18
C	900504	25	105	454	1.640	0.420	172	5,656	0.302	0.017	32	226
C	900507	22	63	52	0.621	0.085	39	356	0.100	0.002	6	10
C	900510	26	62	310	1.908	0.127	118	1,572	1.125	0.145	69	900
C	900513	58	37	152	0.774	0.059	28	162	0.234	0.014	9	25
C	900516	19	45	188	1.005	0.045	45	271	0.235	0.030	11	65
C	900519	15	15	110	0.501	0.035	8	32	0.272	0.015	4	10
C	900522	19	28	121	0.512	0.129	15	120	0.148	0.008	4	8
C	900525	4	3	17	2.308	8.465	8	42	0.439	0.492	1	0